CHANGES IN THE PROTEIN FRACTIONS AND CRUDE FIBER CONTENT OF *PLEUROTUS OSTREATUS* & *STROPHARIA RUGOSOANNULATA* DURING THE DEVELOPMENT

par J. VETTER* and I. RIMOCZI**

SUMMARY — The authors studied the changes in the crude -, digestible - and non digestible protein and the non protein nitrogen values of 2 mushroom species: *Pleurotus ostreatus* (Jacq. ex Fr.) Kummer; *Stropharia rugosoannulata* Farlow ex Murr.).

The examined *Pleurotus ostreatus* has a relative high crude protein content, the main component of which is the soluble, digestible protein (average: 92 per cent). During the analysed four stages of development the second was the best (average cap's diameter: 5-8 cm), here was found the highest crude - and digestible protein level, but the non digestible protein value was similar to the other values. An other characteristic difference: in the fourth stage (cap's diameter: above 10 cm) was the highest non digestible protein content, in the cap and stem, respectively.

The fruit bodies of *Stropharia rugosoannulata* varieties represent a high crude- and digestible protein content. The authors found the highest protein (crude- and digestible) level in the third phasis (in which the cap is fully developed, before the sporulation).

Summarized the experimental data it can be established, that during the formation of mature cap and stem the changes in protein level are characteristic and pregnant. The changes of crude fiber content of *Pleurotus* were unimpor-

* Dep. of Botany, University of Veterinary Sciences, 1400 Budapest, Pf 2. Hungary.
** Dep. of Botany, University of Horticulture, 1118 Budapest, Ménesi u. 44. Hungary.

tant; the *Stropharia*'s fiber content has an increasing tendency in the examined stages. The knowledge of the trend in protein fractions has a physiological and practical (food) importance for the technology of mushroom cultivation, too.

The highest mushrooms belong to the plants having the the highest protein content. This fact gives reason for necessity of the intensive development of mushroom production. On the other hand, because of the possibility of utilization of some kinds of agricultural wastage, it is a very important task to know more about the cultivated mushroom varieties, its physiological characters, nutritional processes, etc. The production (breeding) of new species and varieties and the enlargement of mushroom assortment are very important (BALAZS, 1974; NADABAN, 1976; PHAN VAN UT - SZABO, 1974). In the literature are generally few informations about the changes of different component in mushroom cells (cap and stem) and especiallv we have a poor data about the changes of cap's and stem's protein content under the fruit body development (on oyster mushroom: ZADRAZIL, 1973; on *Stropharia* : ZADRAZIL - SCHLIEMANN, 1975; LELLEY, 1976). From the human nutrition's point the changes of digestible protein and crude fiber content of fruit bodies are very important. In our earlier work (RIMOCZI - VETTER, 1976) eight different oyster mushroom varieties (strains) were compared on the basis of crude-, digestible-, non digestible protein, non protein nitrogen and crude fiber content of cap and stem. The similarity and differences between the morphological, ecological and chemical parameters were evaluated and discussed, too. The aim of our experimental series was to determine the changes of crude and digestible protein, non protein nitrogen and crude fiber content during the fruit body development of oyster mushroom (*Pleurotus ostreatus*) and *Stropharia rugosoannulata*.

MATERIAL AND METHODS

The variety number 5 of oyster mushroom was cultivated on substrate used in the large scale farming (Duna Co-operative Farm, Budapest), in the Botanical Garden of the University of Horticulture. The cultivation of Gelb and Gartenriese varieties of *Stropharia rugosoannulata* was carried out according to Mr. Ede VÉSSEY advice on barley and wheat straw. The *Pleurotus* samples of four different development stages are analysed, I: the cap is closed or weakly opened, II: the cap is fully opened, the lamellae are light, before the sporulation, III: the cap is normally developed, before the falling of spores, IV: the falling of spore is strong, the cap became plain. In the Gelb varieties case, because of great length of fruit bodies, it seems practical to separate further groups. In the case of *Pleurotus ostreatus* the grouping was made on the basis of cap's size, I group: under 5 cm. II: from 5 until 8 cm, III: from 8 till 10 cm, IV: over 10 cm. The caps and stems were separated, after drying the material was grounded. The crude protein content was determined after acidic (sulphuric acid)

digestion with Nessler reaction, the digestible protein according to earlier used method (RIMOCZI - VETTER, 1976). This in vitro digestion was carried out with pepsine, in the presence of hydrochloric acid (48 h, 37°C). From the difference of crude protein and residual (after digestion) nitrogen values was calculated the digestible protein content of the actual samples. After an alcalic digestion of the residue was measured the non protein nitrogen value. After an acidic (1,25 % sulphuric acid), alcalic (1,25% KOH) and water cooking the crude fiber content was measured.

RESULTS

The changes of protein fractions of *Pleurotus* (fig. 1) cap and stem are illustrated on the second figure and are summarized in the table 1. The highest values were found in the second (cap) and in the first phase (stem), respectively. The ratios of cap's and stem's protein values are: 1,79; 3,03; 2,99 and 2,99. The trend of changes in digestible protein is similar to the crude protein, the maximum value of cap was in the second phase (484,3 mg/g dry w.) and in

		PHASIS OF DEVELOPMENT											
		I		II		III		IV/A		IV/B		IV/C	
		Cap	Stem	Cap	Stem	Cap	Stem	Cap	Stem	Cap	Stem	Cap	Stem
Crude protein /mg/g dry w./	1	411,4	173,4	409,1	189,6	459,5	184,2	391,9	208,3	-	-	-	-
	2	529,8	260,2	583,9	373,2	717,2	396,2	461,8	347,2	459,0	359,7	514,7	411,7
	3	421,4	235,1	516,6	170,0	456,5	152,3	443,5	171,6	-	-	-	-
Digestible protein /mg/g dry w./	1	371,1	134,9	348,2	144,3	401,5	143,5	324,5	162,8	-	-	-	-
	2	495,7	210,8	537,3	331,2	651,3	347,3	392,6	309,2	408,0	307,1	432,6	363,1
	3	388,2	210,9	484,3	141,9	424,9	129,2	384,3	132,9	-	-	-	-
Non digestible protein /mg/g dry w./	1	26,9	20,6	32,3	12,4	29,2	11,7	31,2	10,0	-	-	-	-
	2	12,1	9,3	15,6	1,0	29,2	3,1	22,8	6,9	14,9	3,2	27,1	6,0
	3	24,8	17,7	24,6	20,3	24,5	16,4	53,0	31,6	-	-	-	-
Non protein N /mg/g dry w./ in protein value	1	2,5	2,9	4,5	5,1	4,6	4,6	6,2	5,7	-	-	-	-
	2	3,5	6,4	4,9	6,0	5,3	7,4	5,0	5,7	4,9	8,0	8,8	8,0
	3	0,9	1,0	1,3	1,2	1,1	1,1	0,9	1,1	-	-	-	-
Crude fiber /in per cent of dry weight/	1	5,8	11,4	9,0	11,5	9,8	10,8	12,7	11,0	-	-	-	-
	2	9,3	11,2	11,4	5,0	12,9	8,4	16,2	5,2	10,0	9,7	17,4	10,1
	3	3,9	6,5	5,3	5,5	5,2	4,6	4,4	6,0	-	-	-	-

Table 1. — The crude-, digestible-, non digestible protein, non protein nitrogen and crude fiber content of examined mushrooms in different stages of development. The mushrooms are: 1. *Stropharia rugosoannulata* variety Gartenriese; 2: *Stropharia rugosoannulata* variety Gelb; 3: *Pleurotus ostreatus* variety N° 5.

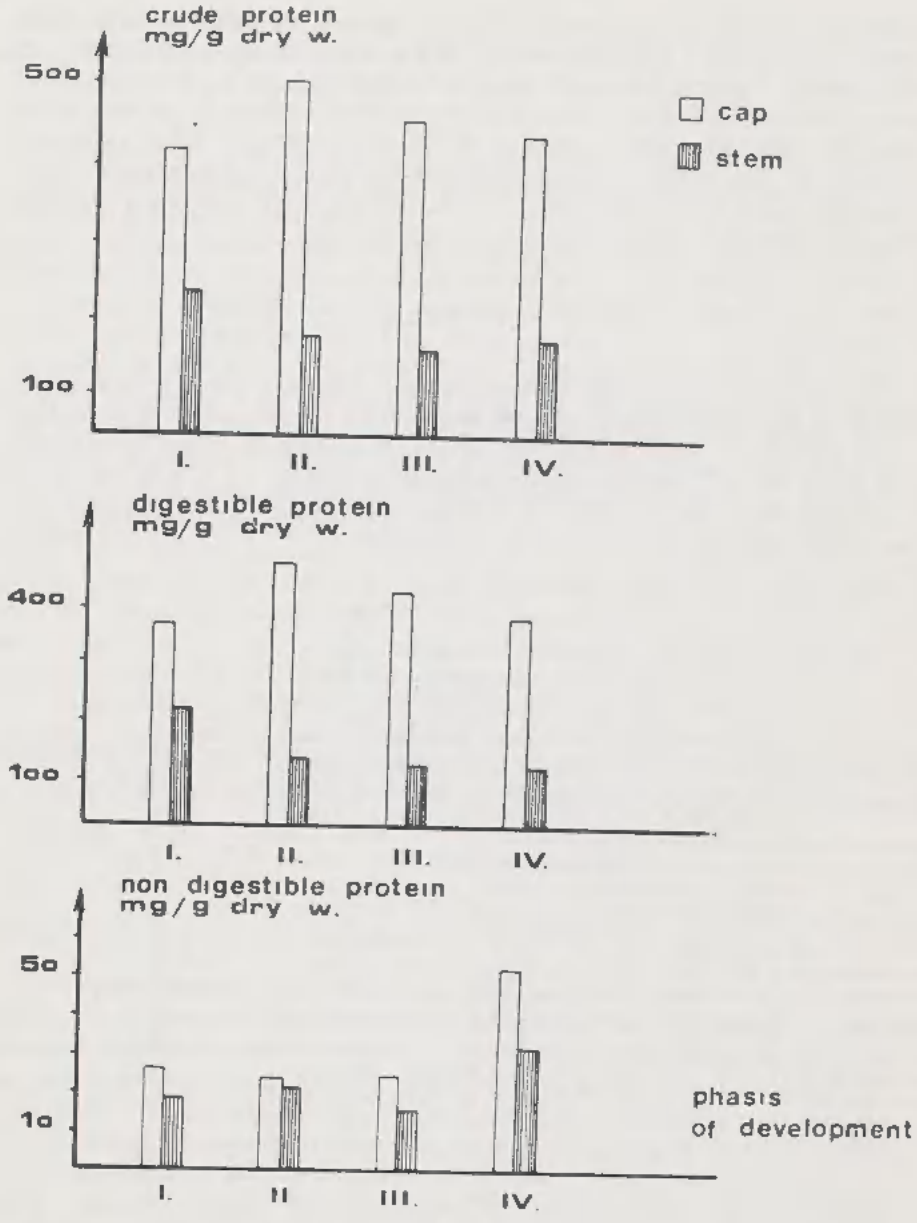


Fig. 1. — The changes of crude-, digestible- and non digestible protein of oyster mushroom during the development (Phasis of development : see the text).

the case of stem was in the first phase (210,9 mg/g dry w.). The differences of the individual development phasis are unimportant. The fourth phase showed

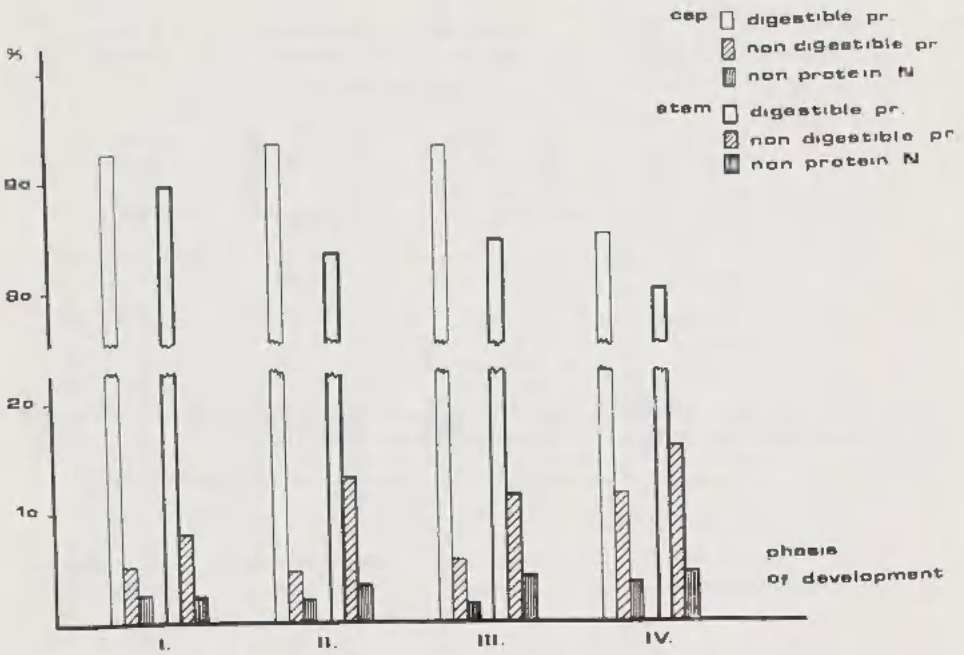


Fig. 2. – The percentage distribution of different protein fractions in cap and stem of oyster mushroom in four development stages.

a significant increase in the non digestible protein content, the values are then 11,9 % (at the cap) and 18,5 % (at the stem) of crude protein (fig. 2, table 2). The other examined parameters are unchanged in all development stages.

The both examined *Stropharia* varieties can be seen on figure 3. In the first table and on fig. 3 are summarized the data of Gelb variety of *Stropharia*. The average value of crude protein content comparing with other examined mushroom species and varieties are very high, that shows the importance of two parts of this species. The crude protein content of cap is in the third phase very high and the other fractions are high too. The crude fiber content did not connect with the development phasis. In the percentage distribution of protein fractions (table 3 and fig. 4) a decreasing tendency was showed in the digestible protein and an increasing tendency of non digestible protein. The crude protein in the stem is varied between 347-411 mg/g dry weight, without a characteristic maximum.

The data of Gartenriese variety are illustrated on fig. 5. The level of cap's crude protein is constant, 400 mg/g dry weight, in the third phasis only was a higher value. The higher value of this phasis differs significantly from the previous and following phasis. The parameters of digestible protein have a

Phasis of development		Digestible protein	Non digestible protein	Non protein nitrogen
		(in per cent of crude protein)		
I	Cap	92,1	5,9	8,4
	Stem	89,7	7,5	6,6
II	Cap	93,7	4,8	7,6
	Stem	83,5 83,5	11,9	7,7
III	Cap	93,2	5,4	7,0
	Stem	84,9	10,8	6,7
IV	Cap	86,8	11,9	6,1
	Stem	77,8	18,5	6,9

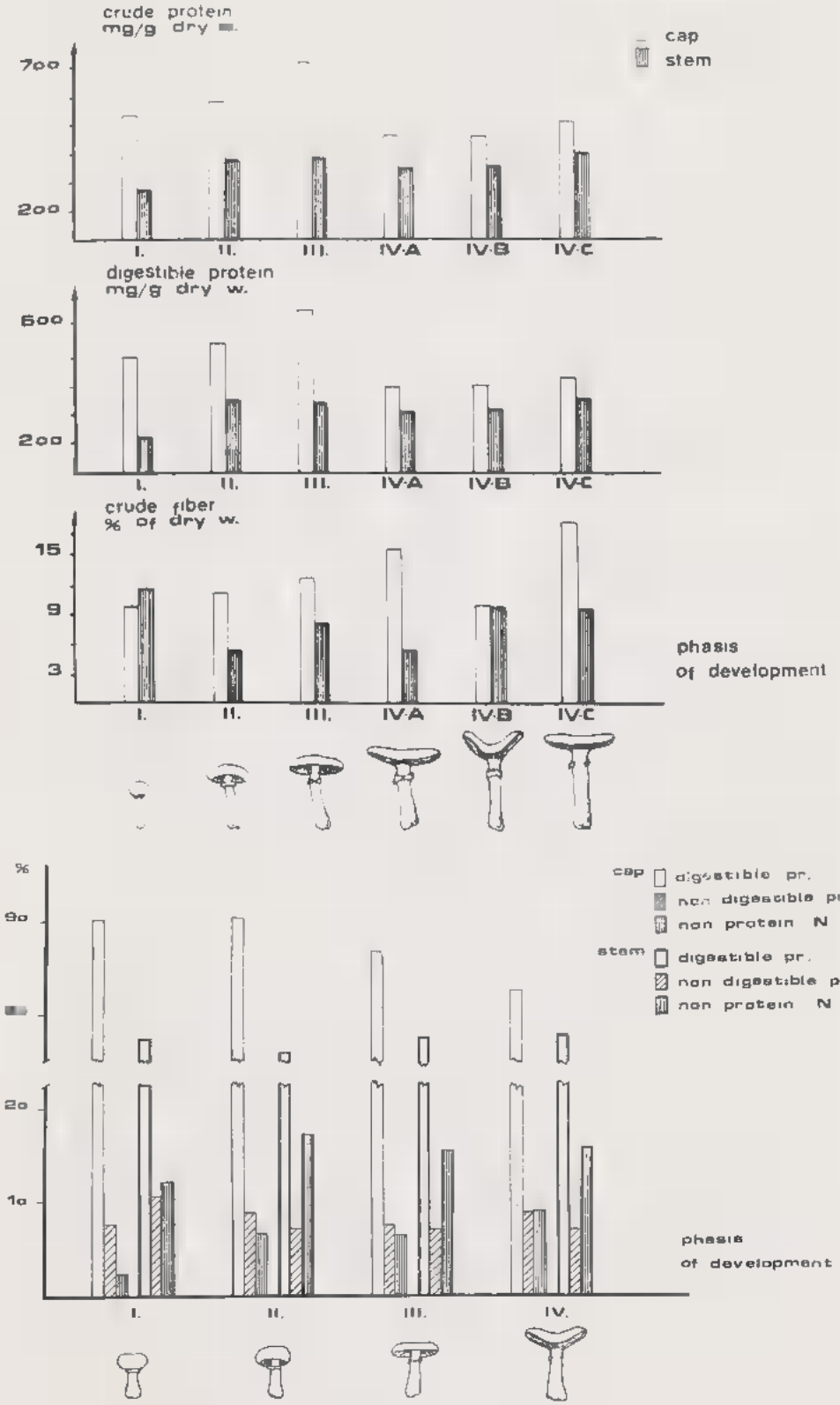
Table 2. – The percentage distribution of protein fractions in cap and stem of *Pleurotus ostreatus* during the development (the total crude protein = 100%).

Phasis of development		Digestible protein	Non digestible protein	Non protein nitrogen
		(in per cent of crude protein)		
I	Cap	93,7	2,3	4,0
	Stem	81,1	3,6	15,3
II	Cap	92,2	2,7	5,3
	Stem	88,7	0,3	1,6
III	Cap	90,7	4,1	5,1
	Stem	87,7	0,8	1,8
IV/A	Cap	86,2	5,3	9,3
	Stem	89,1	2,0	8,9
IV/B	Cap	88,9	3,3	7,8
	Stem	85,5	0,9	13,7
IV/C	Cap	84,2	11,9	4,6
	Stem	88,4	1,5	1,9

Table 3. – The percentage distribution of protein fractions in cap and stem of *Stropharia rugosoannulata* variety Gelb, during the development (the total crude protein = 100%).

Fig. 3. – The values of crude and digestible protein and crude fiber content of *Stropharia rugosoannulata* variety Gelb in different development stages (See the text).

Fig. 4. – The percentage distribution of crude protein content of *Stropharia rugosoannulata* variety Gelb, in cap and stem, during the development.



Source : MNHN, Paris

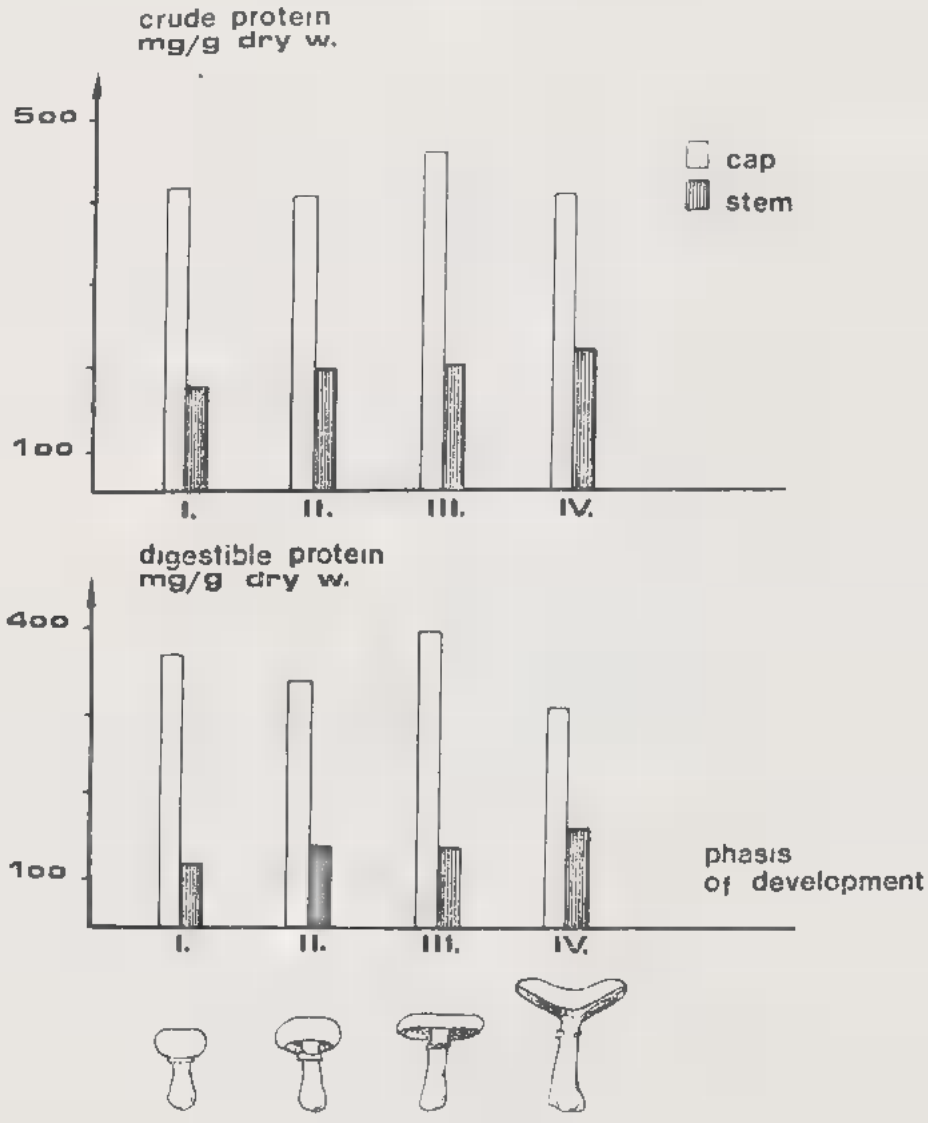


Fig. 5. — Crude and digestible protein's values of *Stropharia rugosoannulata* variety Garten-riese, in four different development phasis (see the text).

similar picture, the other parameters are unchanged. In the ratios of protein fractions (table 4, fig. 6) a decrease of digestible- and an increase of non digestible protein could be observed. The crude protein values of stem are nearly the half of cap's values and have a constant or weakly increasing tendency.

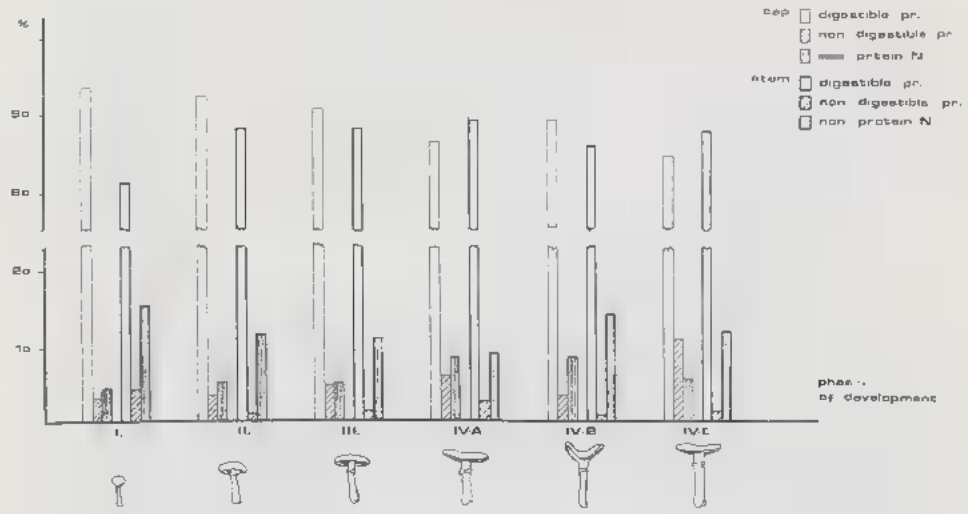


Fig. 6. – The distribution (in per cent) of crude protein in caps and stems of *Stropharia rugosoannulata* variety Gartenriese during the development.

Phasis of development		Digestible protein	Non digestible protein	Non protein nitrogen
		(in per cent of crude protein)		
I	Cap	90,3	6,5	3,2
	Stem	78,0	11,9	10,0
II	Cap	85,1	7,9	6,9
	Stem	76,4	6,6	17,0
III	Cap	87,4	6,4	6,2
	Stem	78,0	6,3	15,6
IV	Cap	83,0	8,0	9,0
	Stem	78,3	4,8	16,9

Table 4. – The percentage distribution of protein fractions in cap and stem of *Stropharia rugosoannulata* variety Gartenriese, during the development (the total crude protein = 100%).

DISCUSSION

The development of mushroom cultivation and the great possibilities of this, turn the attention to what changes of main chemical parameters happen during the fruit body development and age. With the help of such kind of

Planche 1. – 1: the fruit bodies of oyster mushroom (*Pleurotus ostreatus* (Jacq. ex Fr.) Kummer), variety n° 5, used in the experiments. 2: the fruit bodies of the two examined varieties of *Stropharia rugosoannulata* (Gartenriese and Gelb).

investigations one can obtain informations about the metabolic background of fruit body production and we can determine the optimal time of crop harvesting. This is the time, when the customer can get the mushroom with the highest protein content.

At the examination of the two *Stropharia* varieties the authors could establish different development characters. In case of Gelb variety, the initial protein level increases equally till the beginning of spores maturation (the II stage). In the case of Gartenriese there is not such a change. The optimal time of harvesting - considering the wish of maximal protein production - is the fourth phasis. For the Gelb variety the highest protein content can be reached in the third phasis. On the basis of similar points of view, the optimal data of harvesting are in the second phase (the cap's diameter: from 5 till 8 cm), in case of *Pleurotus ostreatus* variety five.

The results of our experiments related to changes of actual protein content during the fruit body production characterize not only the fruit production but have a direct practical importance. The investigations of cap and stem of our cultivated mushroom are also important because of the lack of basic data.

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